What Users Want a Spectrum Sharing System to Do

Briefing to:
ISART 2015
New Radio Technologies

May 14, 2015

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What Users Want a Spectrum Sharing System to Do

- Integration costs
- Operational costs
- Privacy and security issues
- Enforcement
- Flexibility in future operations
- Spectrum availability and reliability

DFS (Dynamic Frequency Selection) - 2003

Requirement	Performance
Integration costs	Requires changes to end user device
Operational costs	Minimal costs
Privacy and security issues	Revealed minimal information on DoD radars
Enforcement	Puerto Rico fiasco
Flexibility in future operations	Detectors hard wired, difficult to account for legacy system changes
Spectrum availability and reliability	Sensing-based detection accounts for all propagation factors

Only commercially and regulatory proven approach, deployed in large quantities, world wide

http://www.ntia.doc.gov/legacy/ntiahome/press/2003/5gHzAgreement.htm

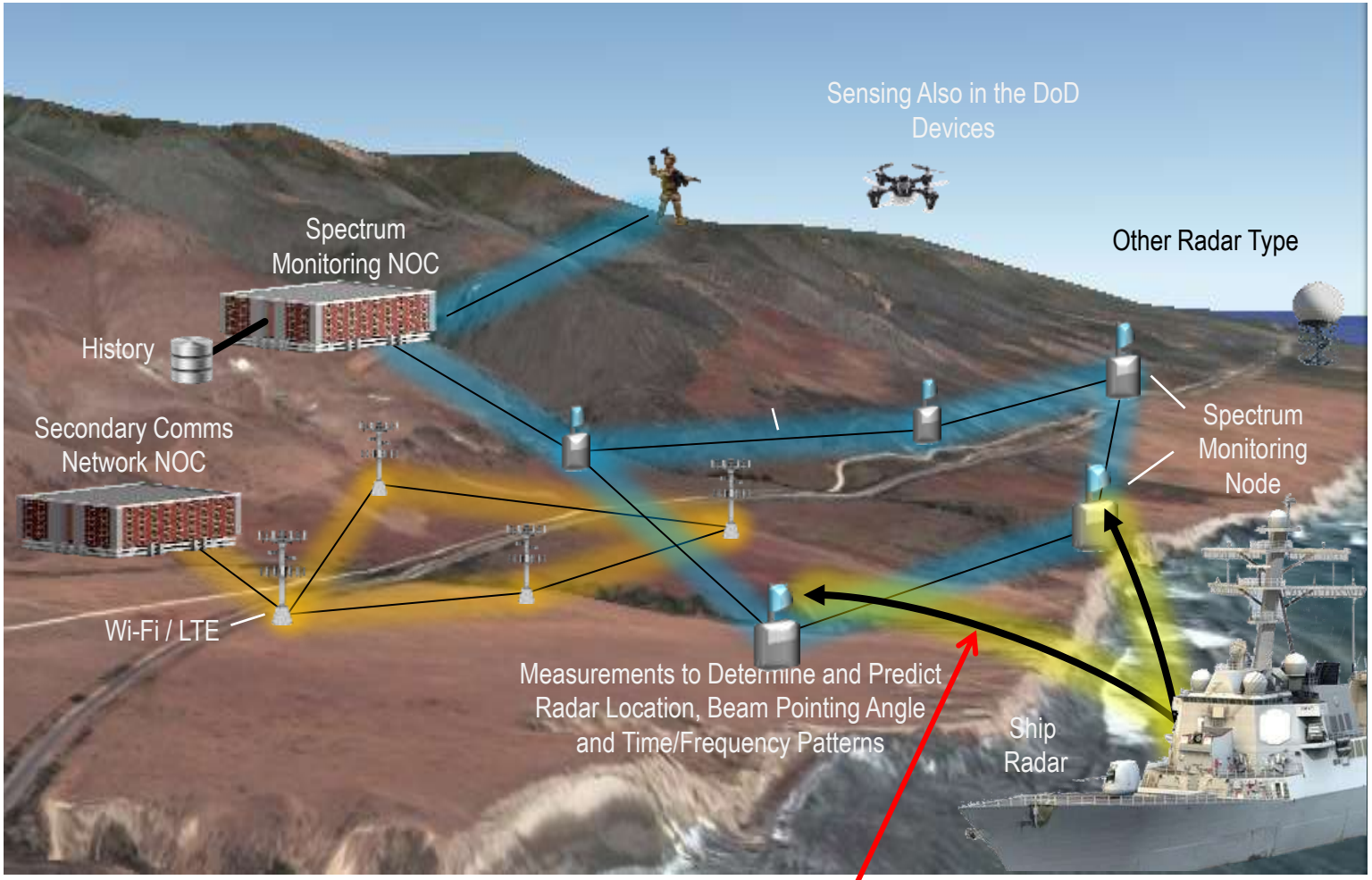
TVWS (TV White Space) - 2008

Requirement	Performance
Integration costs	
Operational costs	Requires internet connectivity, database operations
Privacy and security issues	Reveals information on entrant devices
Enforcement	Able to switch devices off, no diagnostics
Flexibility in future operations	
Spectrum availability and reliability	Worst case assumptions led to small amounts of spectrum in urban areas

3.5 GHz SAS - 2015

Requirement	Performance
Integration costs	
Operational costs	Requires internet connectivity, database operations
Privacy and security issues	Reveals information on legacy and entrant devices – DoD resistant to provide operational information
Enforcement	Able to switch devices off, no diagnostics
Flexibility in future operations	
Spectrum availability and reliability	Inefficient approach but large amount of available spectrum

“Air-Gap” Spectrum Sharing Architecture



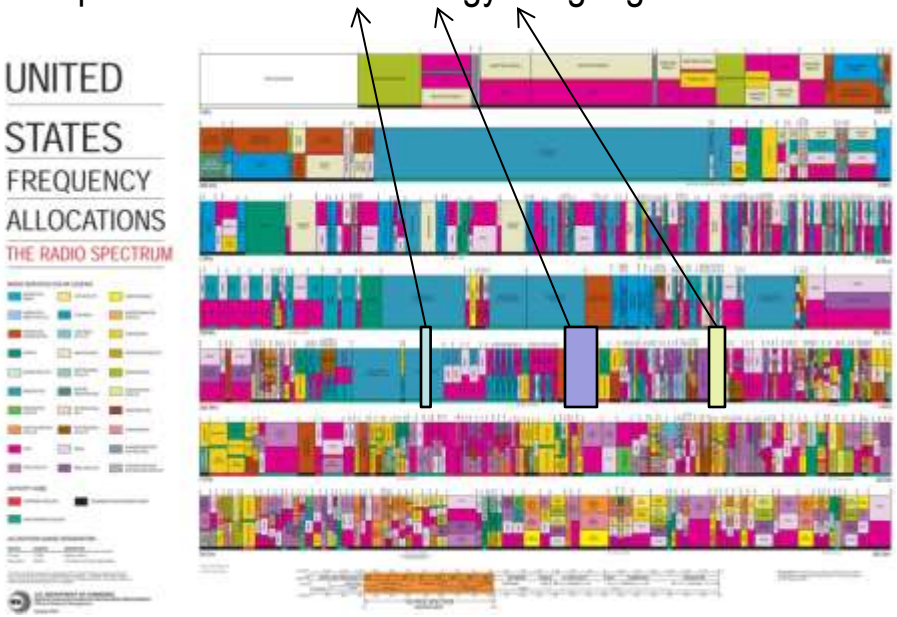
No physical connection to radar

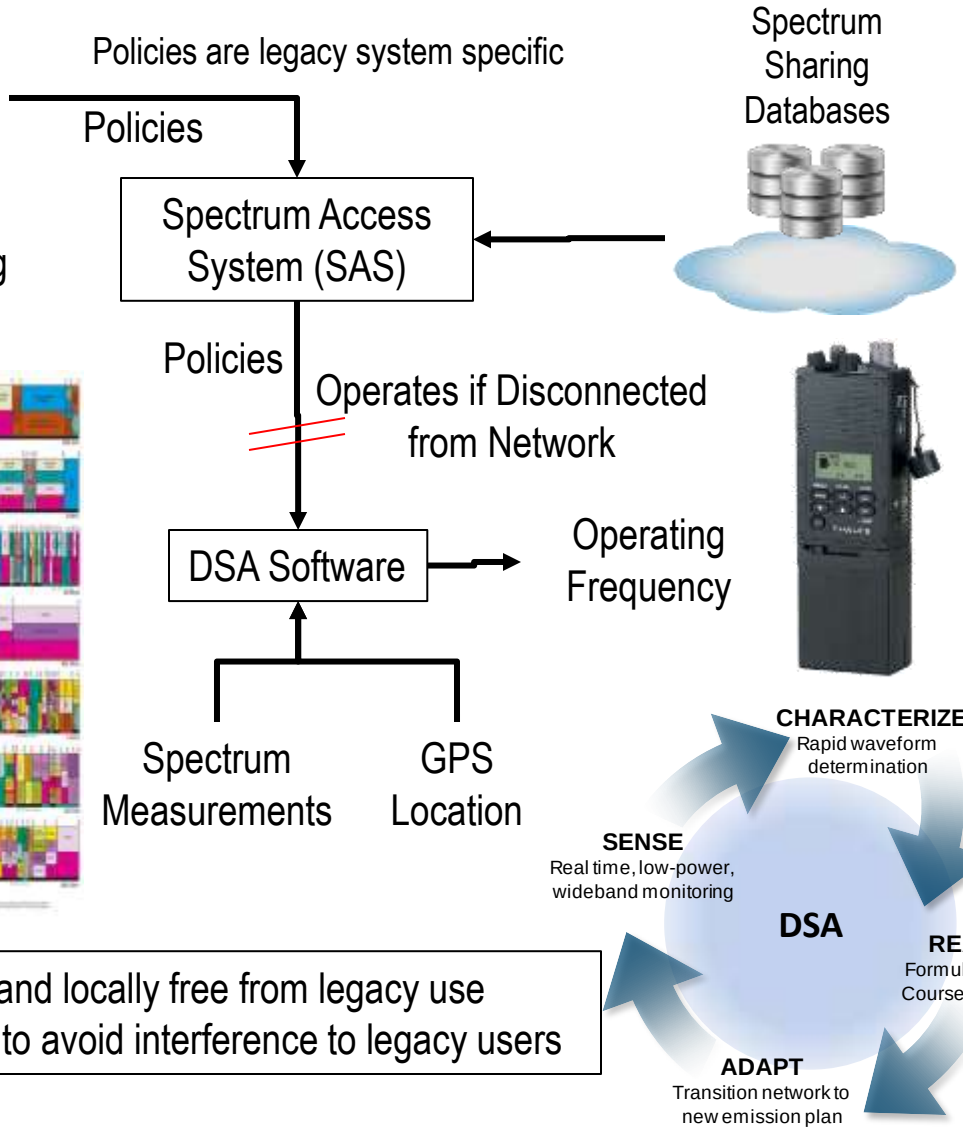
Air Gap Spectrum Sharing Architecture

Requirement	Performance
Integration costs	
Operational costs	Requires external sensors, internet connectivity, database operations
Privacy and security issues	Reveals information on legacy and entrant devices
Enforcement	Able to switch devices off, no diagnostics
Flexibility in future operations	
Spectrum availability and reliability	Inefficient approach but large amount of available spectrum

Policy-Based Dynamic Spectrum Access (DSA) Operation

- Frequency dependent Spectrum Access Policies
- Manage missions across international borders
- Achieve optimal transmit power levels, signal bandwidth, and operating range to avoid harmful interference to legacy users
- Developed by regulators using analysis and testing
- Represented in Web Ontology Language – OWL

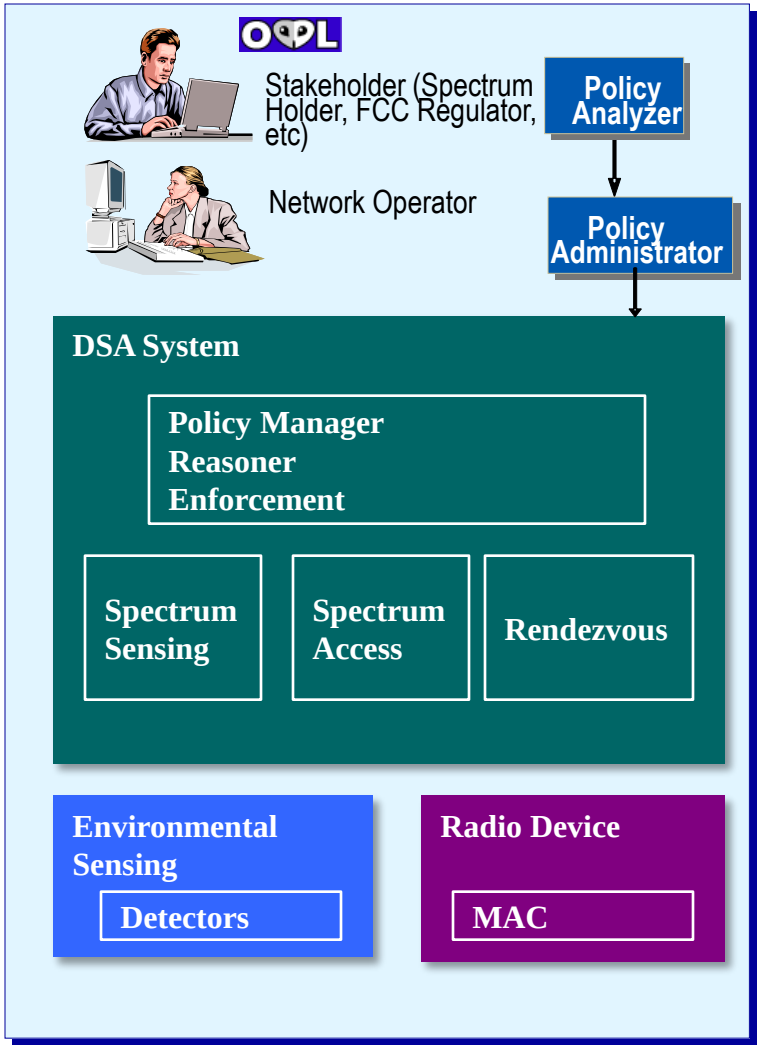




- DSA selects operating frequencies allowed by policy and locally free from legacy use
- If the environment changes, DSA adapts frequencies to avoid interference to legacy users

Policy-Based DSA Software Architecture

- Environmental Sensing detectors measure and assess spectrum
- Spectrum Sensing manages sensing schedules, detection plans, and detection results assessment
- Spectrum Sensing can support local and/or distributed sensing (supports enforcement)
- Spectrum Access provides spectrum allocations or channels to the radio under policy constraints
- The Rendezvous establishes and maintains connectivity to other radios
- The Policy Analyzer validates externally created spectrum access policies for consistency and accuracy
- The Policy Administrator securely disseminates policies using PKI
- The Policy Manager and Reasoner ensures that each DSA radio adheres to the spectrum access control policy rules



Development started with DARPA XG Program – 2004-2008

Policy-Based DSA Is Higher Performance Than DFS

Area	DFS	Policy-Based DSA
Spectrum Sharing Rules	Single sensing-based spectrum sharing rule	Arbitrary spectrum sharing rules including geographic database, time of day, etc
Sensing	Co-channel only	Co-channel, adjacent channel, frequency duplex
Detectors	Energy-based detection based on a list of certain radars	Scheduler supports arbitrary detectors called any place in the spectrum with arbitrary revisit rate
External Control / Database	Not supported	Can change spectrum rules or disable operations remotely
Spectrum Display	None	Provides continuous spectrum display to external laptop using Ethernet connection
Architecture	Sensing on Master Device only	Sensing on all nodes
Architecture	Master / client only	Master / client only and MANET

Policy-Based DSA software has the flexibility to support a wide range of spectrum sharing opportunities

DFS = Dynamic Frequency Selection : 5 GHz commercial standard

Policy-Based Spectrum Sharing Architecture

Requirement	Performance
Integration costs	Requires changes to end user device
Operational costs	Minimal connectivity and database required
Privacy and security issues	Minimize information revealed
Enforcement	Able to switch devices off, sensing can localize rogue users
Flexibility in future operations	Detectors can be updated
Spectrum availability and reliability	Sensing-based detection accounts for all propagation factors

Summary

	2003	2008	2015		
Requirement	**DFS**	**TVWS**	**3.5 GHz**	**Air Gap**	**Policy-Based**
Integration costs					
Operational costs					
Privacy and security issues					
Enforcement					
Flexibility in future operations					
Spectrum availability and reliability					

Progress is Being Made to Meet User Requirements